Green Synthesis of Copper Oxide Nanoparticles Using Datura Stramonium Leaf Extracts

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Abstract- *CuO nanoparticles were prepared by simple and eco - friendly co precipitation method. The prepared CuO nanoparticles were examined by their structural, surface morphological and optical properties by means of XRD, SEM, and UV vis spectroscopy. The XRD pattern revealed that the prepared nanopowder has monoclinic structure. SEM image conform the uniform spherical grains in morphology. The optical band gap of the synthesized CuO nano particles is 1.140 eV. FTIR analysis conform the presence of functional groups.*

Keywords- Green synthesis, CuO, XRD, band gap, monoclinic.

I. INTRODUCTION

Nanoparticles (NPs), controlled to crystalline size less then 100nm, it can exhibit atom- like behaviors which results from higher surface area energy due to their large surface area and short band gap between valence band and conduction band when they are divided into near atomic size [1-3]. The metal oxide NPs syntheses in physical and chemical methods to presented materials are very harmful to the environment, synthesized nanometrials which generates a large amount of hazardous byproduct, and it is used expensive chemicals and starting materials [4]. Thus, there is a need for "green chemistry" because it is clean, nontoxic and eco-friendly method of NPs synthesis [5]. In "green nanotechnology" has been increasing attention towards eco-friendly green synthesis of metal oxide NPs by using plants because the green synthesized NPs do not produce any toxic byproduct and more stable compared chemically synthesized NPs [6, 7].

The development of systematic studies for synthesis of metal oxide NPs play in an important role in many research areas such as physics, chemistry and material science. The metal element able to form a large diversity of oxide compounds. Metal oxides are used in the fabrication of microelectronic circuits, sensors, and piezoelectric devices, fuel cells, coatings for the passivation of surfaces against corrosion and catalysts [8].

Copper oxide (CuO) is a strongly basic oxide. Nanocrystalline CuO is well-defined particle morphology with size shows an excellent optical, thermal, high mechanical, electrical, high oxidation resistance and magnetic properties. Strontium oxides are used in medical applications, such as tissue or body member replacements, restorative implant cement or filling compounds [9].

A number of plants are being currently investigated for their role in the synthesis of nanoparticles. Plants provide a better platform for nanoparticles synthesis as they are free from toxic chemicals as well as provide natural capping agents. Moreover, use of plant extracts also reduces the cost of microorganisms' isolation and culture media enhancing the cost competitive feasibility over nanoparticles synthesis by microorganisms [10]. Plant extract contains a range of biological active compound and it is responsible for the application of anti-bacterial, antioxidant, anti-microbial, aphrodisiac, anti-ulcer, anti-inflammatory, anti-hyperlipidemia, neuro-protector and anti-diabetic properties [11].Plant extract using synthesis of metal oxide nanoparticles are eco-friendly, nontoxic and biocompatible.

Green chemistry approach synthesis of nanoparticles using plant extract is the most adoped method of green, eco-friendly production of nanoparticles and also has a special advantage that the plants are widely distributed, easily available, much safer to handle and act as a source of several metabolites such as alkaloids, phenolic acids, flavonoids, amino acids and triterpenoids in which these compounds are mainly answerable for the oxidation of ionic into formation of bulk metal oxide nanoparticles [12]. In humans, during the last three decades there has been an increase in nosocomial infections that can be life- threatening due to S. marcescens. Even though S. marcescens in environment are frequently red due to their prodigiosin production the nosocomial strains are mostly non-pigmented [13].

II. EXPERIMENTAL DETAILS

Datura stramonium leaves were collected from Pannavayal, Thiruvadanai Taluk, Ramanathapuram District and double distilled water used for the preparation of aqueous

extract. Datura stramonium, known by the common names jimsonweed or Devil's snare, is a plant in the nightshade family. It is believed to have originated in Mexico but has now become naturalized in many other regions. Other common names for D. stramonium include thorn apple and moon flower, and it has the Spanish name toloache. Other names for the plant include hell's bells, devil's trumpet, devil's weed, tolguacha, Jamestown weed, stinkweed, locoweed, prickly burr, and devil's cucumber.

Preparation of Datura Stramonium leaves Extract in Aqueous medium:

Freshly collected Datura Stramonium leaves were cleaned thoroughly by double distilled water several times and then sun dried for 5-7 days. The dried leaves were boiling at 800C for 5 hours. The aqueous extract was filtered whatmann No. 1 filter paper. Then, the extracts were collected in an airtight bottle and were kept in deep freezer for further use.

Synthesis of copper Nps from leave extract:

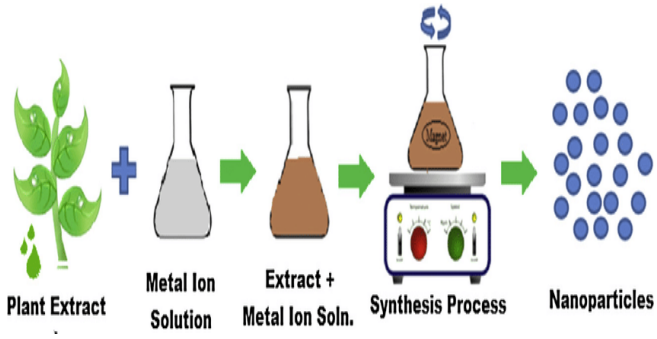

Figure 1. Green synthesis mechanism

Figure 2 shows the basic mechanism of preparing nanoparticles form plant extracts. Copper oxide Nps were prepared by greener co-precipitation method using cupper acetate and Datura Stramonium leaf extract. Copper acetate (Cu) 0.3 M dissolved in deionized water. The reagent, 30 mL of leaves extract is added to the precursor solution. The reduction of copper acetate to copper ions is identified the color changer form light blue color of the extract to dark black color the vigorous stirring for 5 hours at temp maintained at 80^0C. Then the solution settles for 24 hours before centrifugation. The particles were separated by centrifuged at 600 rpm for 20 minutes and the resulting samples were filtered, washed with distilled water and dried in a hot oven at 100^0 C to evaporate water. The obtained powdered sample was finally, grinded using mortar and pestle and calcinated in a muffle furnace for 5 hours at 700^0C to get copper oxide Nps.

III. RESULT AND DISCUSSION

X-ray Diffraction analysis

The formation of crystalline CuO NPs was analyzed by X-ray diffraction studies. The X-ray diffraction peaks of CuO NPs synthesized by using Datura Stramonium leaf extract is shown in Figure 2. The XRD peaks are located at (2θ) 32.49^o, 35.46^o, 35.49^o, 48.72^o, 53.45^o 58.33^o, 61.53^o, 67.94^o, 68.09^o, 72.42^o and 75.03^o corresponding to (*hkl*) values (012), (002), (111), (202), (020), (202), (113), (113), (220), (311) and (004) planes clearly indicate the formation of CuO NPs. The characteristic diffraction peaks of Copper oxide NPs are well matched with the standard powder diffraction JCPDS data card no: 45-0937, with cell dimension α = 6.118 and wave length β = 99.549 angles. The values of a = 4.685 and c = 5.130. The standard diffraction peaks show that Cupper oxide NPs has the monoclinic structure.

The crystallite size of the prepared sample is calculated from the Debye-Scherer's formula. Let λ be the wavelength of X-rays used and β and θ are full width at half maximum and Bragg's angles corresponding to the maximum intensity peak. The Debye-Scherer's (DS) formula [14] is given as,

$$D = \frac{k\lambda}{\beta Cos\theta}$$

According to uniform deformation model, we consider the prepared material is isotopic in nature and the strain is assumed to be uniform in all crystallographic direction. The Williamson-Hall equation according to UDM is given by [15]

$$\beta_{hkl}\cos\theta_{hkl} = \frac{K\lambda}{D} + 4\varepsilon \sin\theta_{hkl}$$

Dislocations an imperfection in crystal associated with the misregistry of lattice existing in different parts of the crystal. Dislocation density (δ) was evaluated using the relation [29]

$$\delta = \frac{1}{D^2}$$

The strain (ε) is calculated from the following relation

$$\varepsilon = \frac{\beta\cos\theta}{4}$$

The X-ray diffraction peak of films corresponding texture coefficient (T_C) is estimated using an expression [16]

$$T_c(h_i k_i l_i) = \frac{I(h_i k_i l_i)}{I_0(h_i k_i l_i)} \left[\frac{1}{n} \Sigma \frac{I(h_i k_i l_i)}{I_0(h_i k_i l_i)} \right]^{-1}$$

where I_0 represents the standard intensity, I is the observed intensity of $(h_i k_i l_i)$ plane and n is the reflection number.

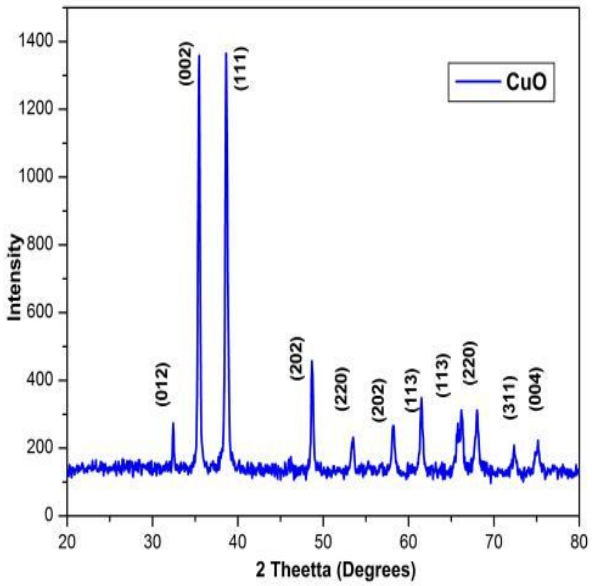

Figure 2. X-ray Diffraction pattern of CuO

Table 1. Micro - structural parameters of CuO nanoparticles

Micro-structural properties	**CuO Nanoparticles**
Crystallite Size using Debye - Sherrer's formula (nm)	32.74
Crystallite Size using Williamson - Hall equation (nm)	42.10
Dislocation Density (δ) X 10^{14} / m^2	9.32
Strain (ε) X 10^{-3}	2.80
Texture coefficient	1.32

FTIR Spectroscopic analysis

Fourier transform infrared (FTIR) spectroscopy was done to identify the chemical functional groups present in the Datura Stramonium leaf extract and the prepared Copper oxide NPs. The FTIR spectra of green synthesized CuO nanoparticles are shown in Figure 3. It clearly Shows bands at around 423.3 cm^{-1}, which can be assigned to the vibrations of Cu (II)-O bonds. There is sharp peak observed at 601 cm^{-1} in the spectrum CuO nanoparticles which is the characteristics of Cu-O bond formation. The bonds appearing at 1572 cm^{-1} and 1323 cm^{-1} are attributed to the formation of oxygen functional groups like highly conjugated C=O stretching mode and N=O bending nitro groups respectively. The broad absorption peak at around 3489 cm^{-1} is caused by the adsorbed water molecules since the nano crystalline materials exhibit a high surface to volume ratio and thus absorbs moisture.

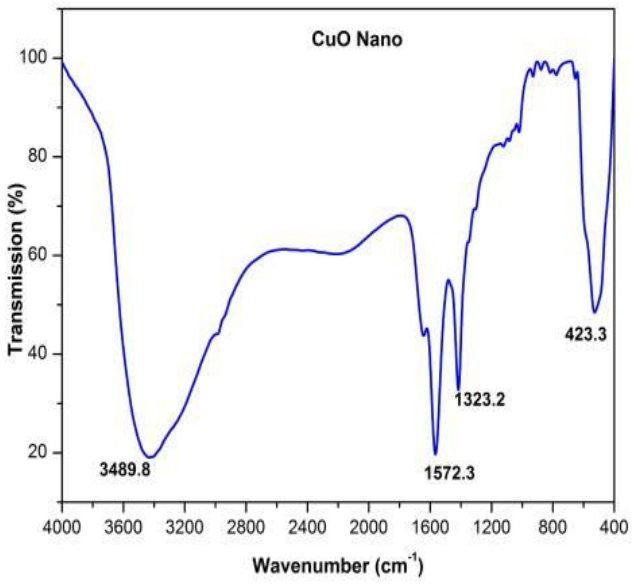

Figure 3. FT-IR Spectra of green synthesis of CuO

UV-Vis- spectroscopy analysis

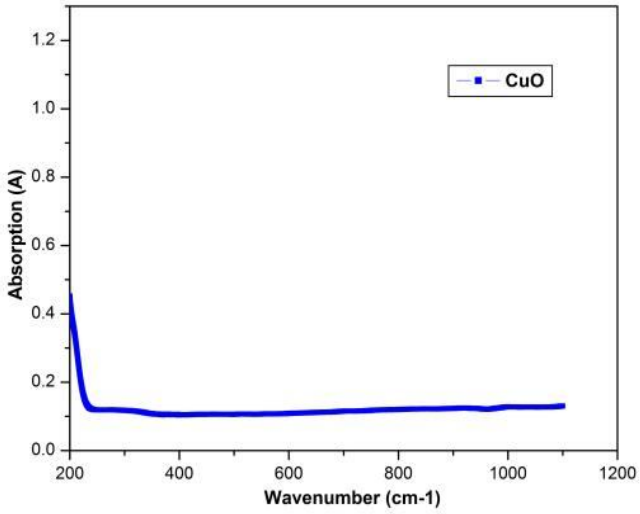

Figure 4. Absorption Spectrum of green synthesis of CuO

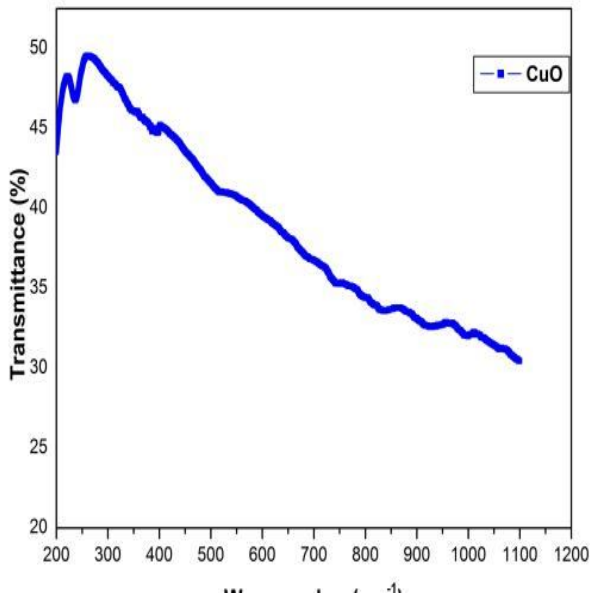

Figure 5. Transmittance Spectrum green synthesis of CuO

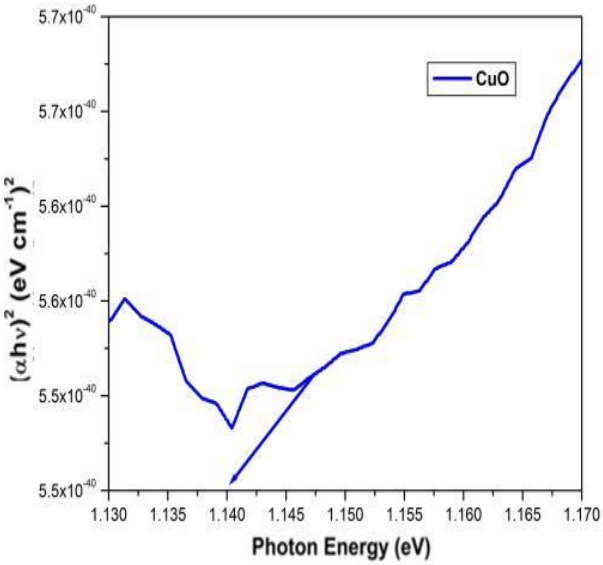

Figure 6. Tauc plot for green synthesis of CuO

Figure 4 shows the absorption spectra of green synthesized CuO. The maximum absorption takes place in the range of 250 nm. In the transmittance spectra (figure 5) the maximum transmittance value is greater than 55%. It occurs in the wavelength of 250 nm. The variation of $(\alpha h\gamma)^2$ with photon energy $h\gamma$ for the Copper oxide NPs presented in Figure 6. From figure 6 the optical band gap energy of copper oxide NPs band gab energy 1.140 eV is decreased compared to bulk CuO band gap energy 1.21 eV. This behavior may be associated with the structural changes occurring after addition two metal oxides. This change which indicates a lowering in energy band gap leads to an increase in the electrical conductivity of the NPs. This decrease in the optical energy values is due to formation of defects in the Copper oxide and consequently influences the optical properties of materials. In the studied range of wavelength (200- 2500 nm), the absorption bands are associated with π-π^* electronic transition. The excitation of π electron requires smaller energy and hence transition occurred in longer wavelength. In the high absorption region where absorption is associated with inter band transition. This decrease of band gap may be attributed to the presence of unstructured defects. This defects lead to the formation of lower energy states resulting in the increase in the number of charge carries in the conduction band which increases the density of localized states in the band gap and subsequently increase in grain size CuO.

Scanning Electron Microscopy

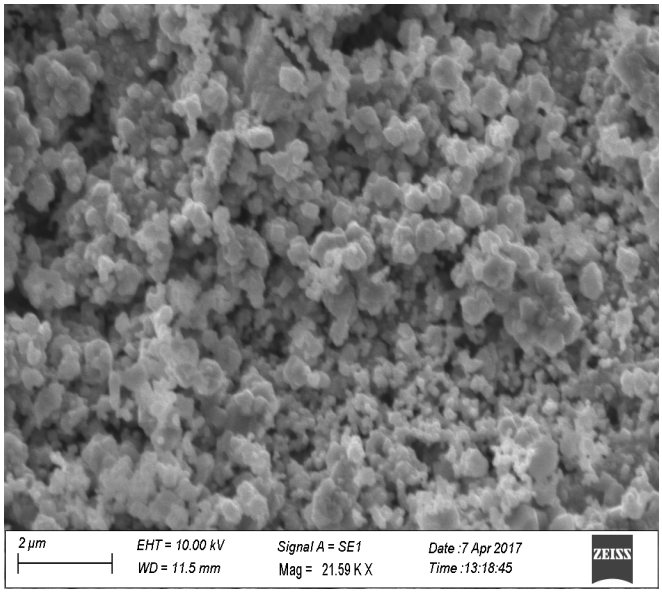

Figure 7. SEM images of green synthesized CuO (2 µm)

Shape distribution and surface morphology of green synthesized copper oxide nanoparticles was studied by using scanning electron microscopic technique (SEM). Figure 7 shows the SEM micrographs of copper oxide nano particles with 2µm. From those micrographs it is observed that, there is a formation of uniformly packed particles is observed throughout the surface. Evidence from the micrographs the copper oxide has spherical nano grains like morphology. The particles uniform and regular distribution is due to the structurally aligned nature of plant extract. That also controls the particle size, growth and agglomeration and act as a capping agent.

IV. CONCLUSION

CuO nanoparticles were synthesized by simple co precipitation method by using Datura Stramonium leaf extract.

XRD studies show that the prepared samples were polycrystalline in nature with monoclinic structure having preferential orientation along (0 0 2) plane. It is observed from the SEM images and XRD patterns that the grain sizes of the structures were nearly 40 nm. The optical transmittance in the visible range is greater than 55%. The optical band gap of the synthesized CuO nano particles is 1.140 eV is decreased compared to bulk CuO band gap energy 1.21 eV. FTIR analysis conforms the functional groups presents in the prepared nanoparticles.

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